ON THE SUBJECTIVE CAUSES OF EVOLUTION AS ILLUSTRATED BY THE GEOGRAPHICAL DISTRIBUTION OF PLANTS.

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[Read 25th April, 1888.]

INTRODUCTION.

When a seed germinates the character of the plant that will be evolved depends both on the nature of the seed and on its environment.

The first may be called the *subjective*, the latter the *objective* cause of the plant's ultimate form.

Soil, moisture, light, temperature, as well as man's direct interference in training and pruning, may make all the difference between a stunted pot plant of a few inches high and a magnificent forest tree. But whatever differences may thus be objectively produced there are certain unchangeable subjective characteristics due to the nature of the seed itself which cannot be altered. No cultivation for example will evolve a fir tree from an acorn.

It is now generally believed, and will here be assumed, that existing species of plants and animals have been evolved from dissimilar pre-existing species, and the question arises to what extent the forms of existing species are due to subjective as well as objective causes, that is to say to what extent the forms of existing species are due to the subjective tendency or capability of the ancestral species from which they have been evolved of varying in what may be called *prescribed* ways, or whether there is no such prescribed capability or tendency and whether evolution is due to environment only.

Darwin's theory of evolution by natural selection seems to have left this question open. His own views seem to have undergone a change between the dates of the publication of the first and last edition of the "Origin of Species." At the date of his first edition (1859) he seems to have been disposed to account for evolution almost entirely on objective grounds, whereas at the date of his last edition (1886) he clearly laid more stress on subjective causes of evolution.

It is true that the only subjective element of evolution he expressly

recognises is that of hereditary influence, but he does not seem to deny the possibility of the existence of other subjective tendencies.

My object in the present paper is to enquire how far the geographical distribution of plants and other organisms on the earth's surface throws light on this question. With respect to the distribution of plants the phenomena to be accounted for are as follows :

(1.) Large numbers of identical and of closely allied genera and species of plants often extend over continuous areas possessing more or less uniform physical conditions.

These areas are called Floral Areas. Schouw divides the surface of the earth into twenty-five Floral areas, defining a Floral area as being a region in which :

I. At least half the known species are endemic.

II. A fourth part of the genera are endemic or nearly so.

III. The orders are either peculiar to the region or have their maximum there.

(2.) Identical and closely allied genera and species occur in widely separated areas having similar physical conditions. Thus :

I. Two-thirds of the Antarctic genera and at least thirty species are common to that region and Europe.

II. Between forty and fifty flowering species of Tierra del Fuego are European.

III. Half the genera of extra-tropical South America are European.

IV. Half the genera of New Zealand are common to Europe.

V. Several so-called European species are found on the Australian Alps.

(3.) Regions very similar in climate and other physical conditions have very different Floras : Thus :

I. North America and Europe.

II. Mexico, South Africa and Australia.

III. Tropical Africa, Tropical America and the Moluccas.

There are two theories to account for these facts :

(*a.*) The theory of local origin and migration.

(*b.*) The theory of simultaneous evolutionary development.

These two theories are not absolutely exclusive of each other, but they depend on somewhat different views as to the origin of species.

There are however certain common grounds of agreement which it will be expedient first to mention.

These are as follows .

(1.) There is no essential difference, but one of degree only, between variety and species and between species and genus.

(2.) Existing specific forms ha ve in some way been evolved from specifically different pre-existing forms.

(3.) The process by which existing species have been evolved is wholly or partially what Darwin has called "natural selection" (including in this term for convenience sexual selection also).

The points in which the two theories differ are as follows :

(1.) According to the migration theory variations are due to environment only or to causes so obscure that they may conveniently be ascribed to chance. They are all-round in character and almost infinite in number, and there is no natural tendency or capability of varying in any prescribed directions.

Similar variations *may* be produced simultaneously in different regions from similar environment, but as the combinations of external circumstances are practically infinite, as are likewise the possible variations of the species, the chances of the same varieties and species beingevolved simultaneously and independently are infinitesimal.

The theory of simultaneous evolution on the other hand depends on the following hypothesis :

(2.) Variations, being correlative, are only possible in a comparatively limited number of directions and naturally tend to follow certain lines, so that amidst circumstances not too dissimilar similar variations will occur independently and simultaneously both in the different parts of the same area and even in the different areas over which a species is diffused ; so that a varying species without any necessary intercommunication evolves throughout its area either the same or closely allied species.

According to the migration theory species originating locally have become more or less widely disseminated by migration. The *seat* of the species being generally assumed to be the region in which the species and its congeners are most numerous. Going back to this region and applying the same theory, we have to conclude that the species now distributed over it originated in some limited locality, and continuing the process the species is ultimately traced back either to a number of individuals of the species somewhere simultaneously and independently evolved, or to a single individual ancestor or pair of ancestors, from which all the individuals of the species have come by lineal descent.

The former alternative however seems to be fatal to the migration theory. If in any locality a number of individuals of a species A simultaneously and independently vary either *per saltum* or by degrees, and in the course of many generations into the B form, there seems to be no valid reason why this process should be confined to one locality of the seat or seats of the A species.

If independent simultaneous and similar variation be admitted at all, it seems impossible to deny that it may take place in more than one locality either in the same or different floral areas. The denial of this possibility seems necessarily to involve the hypothesis of species being derived from a single ancestor or ancestral pair.

On the migration theory the existence of the same species in remote areas is accounted for either on the hypothesis of the actual conveyance of seeds or plants over the intervening regions by birds, ocean currents, or otherwise, or on the hypothesis favoured by Darwin and Hooker that the two regions where the common species exist were once united with each other or at different times with some third region by similar climatic and other conditions and thus formed a single floral area, which has since become severed by change in the climate and physical conditions of intermediate regions.

The existence of distinct floral areas under similar physical conditions is not absolutely inconsistent with this theory of the origin of species but presents many difficulties.

European species can and do thrive in America ; and *vice versa*, if their migration on a large scale has been possible between Europe and the Antarctic regions, it is difficult to understand why there should not be a greater community of specific forms in regions so close as Europe, and Northern Asia (which belongs to the European area) and America.

So also if migration were so efficient a factor in the distribution of species as this theory supposes it is hard to understand why so marked a difference should still continue to exist in the fauna and flora of islands belonging to the Moluccan and Australian areas, which are only separated from each other by a narrow strait (see Wallace).

A continuity of physical condition, such as would have connected the Australian Alps and Siberia into one area, would surely have also connected the tropical and sub-tropical regions of Australia and the Moluccas and thus have left far more distinct traces of its existence.

The theory of simultaneous variation accounts for the appearance of the same species both over a continuous floral area and in widely separated areas as follows :

From an ancestral species probably equally widely spread, having everywhere a capability of varying in a limited number of directions and a tendency to vary in still fewer, similar circumstances have over some parts of the area favoured the production and survival here of one variety and there of another. The localities in which the same varieties have been favoured, are not necessarily conterminous or even in the same area. In other places again, circumstances not being favourable to the new varieties, the species has disappeared.

The difference of the flora of regions similarly situated as far as physical conditions are concerned would then be explained as follows :

Two areas, say Mexico and South Africa, have formerly been subject to different physical conditions and have thus developed different specific and generic forms. Owing to change of circumstances the physical conditions of these two regions have subsequently become assimilated to each other. The conditions requisite for the same flora are not then here present. Similar conditions operate on dissimilar forms. In this way not identical but parallel species are produced, resembling each other outwardly but not in the structure of the part on which classification depends. Thus in Mexico we find the succulent Cactaceæ, in South Africa the succulent Euphorbeaceæ.

The theory of the individual or dual origin of species on which the migration theory rests, or rather, perhaps, on which the denial of the plurality of seats for the same species depends, seems to be surrounded with difficulties.

According to this theory either the new species is produced *per saltum* or it is produced from a single line of ancestry which has left no collateral issue.

Either hypothesis is inconsistent with the admitted prevalence of cross-fertilization.

If variations are all-round variations, following no perceptible law and selected by environment only, then where cross-fertilization is the rule every attempt at variation would be swamped, or only those new species would be produced which are self-fertilized, so that cross-fertilization would either become unknown or very rare.

The production of new species *per saltum* is hardly worth serious consideration. In the case of all animals and dioecious plants it would involve the accidental and simultaneous production of two

specifically identical individuals of opposite sexes and specifically differentiated from their ancestors, thus bringing us back practically to the abandoned doctrine of specific creations.

The individual or dual origin of species fails also in satisfactorily explaining the extinction of a varying species.

It seems to be generally held that existing species are collaterally, not lineally, related. Why this opinion is so generally entertained is not very obvious. One reason perhaps is that species are not known to sport into other species, which owing to atavism would sometimes be the case if existing species were related in the direct ancestral line. Now in the absence of a general tendency to variation on one or some few directions, this extinction of the ancestral form is not easily accounted for. If a species diffused over a floral area gives rise to a variety in one particular spot, in the absence of any tendency towards the same variation elsewhere, it seems almost impossible that the new form should supersede the old. As Darwin has pointed out, in order that a species may successfully invade a new region it must not have any closely allied race to contend with.

Successful invaders of an occupied area to a great extent belong to genera not represented in the area they invade, and seldom or never do they belong to species closely allied to species existing there. Still less is it likely that a variety formed in one area will pursue and exterminate the parent species in an area now detached from that in which it originated.

Whatever theory is entertained as to the origin of new varieties must be also capable of explaining the disappearance of the form from which it originated and in this respect the purely objective theory of the production of new forms seems to fail.

According to the theory of variation in a comparatively few directions due to an innate law or tendency, cross-fertilization is a distinct aid to the production of new species and to the extinguishment of the old.

Thus suppose a species A has a natural tendency to vary in a direction which would ultimately produce a new species Z, and let the first step of variation produce the form B. Let A be an annual and let 20 per cent of its progeny take the B form.

Some few of these B's may be cross-fertilized with each other, and their inheriting the tendency to vary from both parents will leave progeny of which the majority will pass into the C form, another step towards the specific form Z. The great majority of the B's, however,

will be cross-fertilized from A's, and about an equal number of the A's from the B's. Of these inheriting on one side the B form and on the other the tendency to the same form, the great majority will be of the B form, while of the A's crossed with A's, another 20 per cent will pass over to the B form. In this way it is obvious that the A form will soon begin rapidly to give way to the B, and subsequent forms tending nearer and nearer to X. We have here been supposing that natural selection does not operate, and that external circumstances are equally favourable to A B and the subsequent forms up to X. If, however, this be not so, if natural selection favours the development towards X, then the evolution of the X species and elimination of the A species will be facilitated. If, however, natural selection be opposed to the B variation, then the A form will simply tend to die out in its attempt to vary in a way in which it is not permitted to vary.

As this tendency to vary is supposed to characterize the species wherever it exists, it is easy in this way to account for the comparatively rapid extinction of a species which is actively varying.

But it may be asked what proof have we of the existence of this capacity to vary in comparatively few directions and tendency to vary in fewer still.

We cannot say that we have any distinct proof of the existence of such laws except in so far as these laws better explain the evolution and extinction of species. Some arguments however may be urged in their support :

(1.) The doctrine of the correlation of organic variation.

This doctrine is not to be confounded with that of the correlation of organs.

Whatever be our theory as to the origin of species or the cause of variation, it is plain that no plant or animal could exist unless its organs were correlated not only with each other but with the environment. Their eyes, teeth, limbs and digestive organs are correlated with each other and the food supply. In order that varieties may subsist they must involve the correlative variation of the necessary organs. The harmony of life must be maintained. Variations opposed to this harmony will be disadvantageous to the individual.

The bare theory of casual variation with natural selection meets this requirement by supposing that among the infinite varieties which are always occurring those only will survive which involve the requisite harmony with each other and the environment.

"Only give us sufficient time," the casual evolutionist would say, "and without requiring any law by which organic variations are harmoniously correlated we can account for the fact that in the outcome they are and must be so related." This is true, but the demand for time becomes excessive.

The correlation of variation of which we are now treating is however something more than this. It is the law by which without reference to natural selection, or the advantage of the individual, one part of an organism cannot vary without involving the variation of other parts also.

This subject has been so fully treated by Darwin that it is hardly necessary to do more than to refer to his works on this subject.

Darwin has shewn that as both animal and vegetable forms, even those most highly developed, consist to great extent of variously developed homologous parts their parts must tend to vary correlatively to each other. Thus, for example, the jaws are related to one of the three modified vertebrae, constituting the skull, in the same way as the fore limbs are to another of these vertebrae and the hind-limbs to one of the sacral vertebrae. Now Darwin points out how breeders have noticed that these parts vary together, so that elongated jaws are generally found with elongated limbs, both fore and hind. Not only however do homologous parts vary together, but the same is the case with respect to parts between which there is no apparent homology, as in the oft-quoted case of white blue-eyed cats being nearly always deaf, and tortoiseshell cats of the female sex.

Again flowers and fruits are modified leaves. The varieties of cultivated fruits have been produced by man's selection with reference to the fruit itself. Yet an experienced horticulturist can distinguish the different varieties from the correlated and unintentional variations of the foliage.

How far-reaching is this correlation of parts is well illustrated by the fact that the experienced *hologist* can reconstruct the entire animal from the fragment of a bone, can tell you not only that it is a bird and not a mammal or reptile, but can tell you to what tribe of birds it belongs, what was its size and its habits. So from a few grains of tenui carbonized wood the phylologist will reconstruct a tree with foliage, flower and fruit.

(2.) The existence of a tendency to vary in certain directions with a capacity of varying in others is well illustrated from the experience of breeders of plants and animals.

Man, selecting for his own purposes, has probably not succeeded in producing a single new species of plant or animal, and probably not a single naturally permanent variety which might be regarded as a step towards a new species.

Unless kept under man's incessant supervision our cultivated plants and domestic animals revert to their ancestral form. Pigeons allowed to breed freely among each other revert to the rock pigeon form, dogs mongrelize towards the " dingo " type.

Not only is this the case, but in proportion as the varieties produced by man's selection deviate more and more from the parent type, so the breed as a rule becomes increasingly difficult to keep up, on account of increased delicacy of constitution and often also diminished fertility.

The explanation of this is that man tries to produce variations which are not in the direction in which the species tends to vary, and the further he proceeds with these variations, which we may call un-natural, the more difficult his task becomes. Not that variations occur less often, for the reverse is the case, but that the variant forms have not those qualities which ensure permanency in the ordinary conditions of life.

Another experience of horticulturists also bears on the same point. It is well known what difficulty there is to get some wild plants to vary when first taken into cultivation. Some have resisted for generations every attempt to produce desired varieties. At last some lucky or more observant gardener detects in some individual a slight tendency to vary in the desired way. Carefully separating this individual and breeding from it, he finds among some of its descendants a further variation in the required direction ; after this the task is comparatively easy. The descendants of those plants which for two or three generations have varied in one direction vary freely, at first in the same direction, and afterwards owing probably to correlation of organs in other ways also. Thus illustrating the fact that the tendency to *variation is hereditary and produces like effects in many individuals.*

(3.) Another observation tending to the same conclusion is the frequent occurrence of well-marked varieties among wild plants growing side by side with apparently identical environment, and the fact that the same varieties also occur independently and in places remote from each other with different environments.

The collection and classification of marked varieties, especially extreme varieties, sometimes called monstrosities, is at present occupy-

ing many botanists, and the mere fact that such varieties can be and are classified and named, seems to prove that varieties are not all round varieties due to chance (unknown law) but to definite laws, which produce like results in places remote from each other.

(4.) The theory of a law of variation in predetermined directions also renders more intelligible the development of organs so complicated and specialized as the eye.

Darwin admits that when he reflected at what an early geological period eyes of apparently perfect organization were produced, he hesitated long to come to the conclusion that mere casual variation and natural selection could have produced them.

The hypothesis of natural tendency to vary in prescribed directions would remove much of this difficulty.

If we imagine that the early and lower forms of animal life were sensitive to light over their entire surface, we can easily imagine that the localization of this sensitiveness increased in degree, and its suppression elsewhere might be an advantage to the animal. Such a change being the first step toward the development of an eye if occurring according to a law, a tendency to vary in a prescribed direction might within a period, not inordinately prolonged, result in the complete perfection of the organ.

(5.) The migration theory supposes that man originated from a single pair of ancestors belonging to some anthropomorphic species now extinct, and that from this pair of ancestors, the Bushman and the Caucasian have both descended. The theory of simultaneous variation merely supposes that the Bushman and the Caucasian have descended from the same ancestral anthropomorphic species but that neither is the Bushman a degenerated Caucasian nor a Caucasian an improved Bushman, nor that the Bushman and Caucasian descended from common ancestors.

It may be urged against the theory of variation by common innate tendency that it only accounts for the existence of widely spread species by supposing the previous existence of an equally widespread parent species.

This is true, but it is hardly a valid objection.

Geology in no very distinct terms perhaps, but still conclusively enough, seems to tell us that the fauna and flora of the world were formerly less diversified than at present: that species and genera if not fewer in number were at least more cosmopolitan in habit than at present: that for example the fauna and flora of

Europe and America were more closely allied than is now the case, that the same was true of North and South America, and of Africa and India.

If this be granted we have no choice as to whether we are to trace existing species to former equally widely diffused species. The problem is thus set as by nature itself. In passing from previous geological times down to the present the phenomenon to be explained is not so much why it is that some modern species are so widely diffused, but why it is that modern species generally have become relatively more localized, why for example the marsupials once abounding elsewhere should now be almost confined to the Australian Area. Whether we adopt the theory of local origin and subsequent migration or that of simultaneous variation the main outlines of the problem are in this respect the same.

It must be remembered that to advocate the doctrine of simultaneous parallel variation as a cause of the co-existence of the same species in remote areas is not to deny that migration or accidental or intentional transport is a cause also. Where the agency of man comes in, the spread of species by migration is a well-known fact, and it is equally well known that the spores of many plants and the seeds of not a few can be carried great distances by the wind, that some seeds are transported thousands of miles by ocean currents, without losing their vegetative powers, and that birds and even insects must sometimes transport seeds.

On the other hand too much stress must not be laid on the effect of the infinite variety of surrounding conditions or the differentiation of nascent species. This variety is, it is true, in one sense infinite but in another sense it is very limited. Climate, soil, and rivalry in the struggle for existence may be varied infinitely but only in infinitely small respects while in those general aspects which favour or oppose the success of a species, the variations are by no means so numerous, otherwise the same species would not sometimes flourish over such large areas as they do, and in such vastly different conditions as to soil, climate and competition, and would not be as capable as they are of rapidly overrunning new areas into which they have been accidentally introduced.

DARWIN'S VIEWS.

Those who oppose the theory of simultaneous development seem to assume that they have the authority of Darwin on their side. This is by no means clear. What Darwin's opinions were on the points we

have been discussing are not so easily ascertained as might be supposed, owing probably to the fact that Darwin's views underwent a change, which he himself admits, between the times of the publication of the first and last edition of the Origin of Species.

I. Thus with respect to the descent of all individuals of the same species from a single ancestor or pair of ancestors, we have the following passages (sixth edition) :

(p. 320). . . . "Individuals of the same species. . . . . must have proceeded from one spot where their parents were first produced."

(p. 259) "If we bear in mind. . . . how often a species may have ranged continuously over a wide area and then become extinct in the intermediate tracts, the difficulty is not insuperable in believing that all the individuals of the same species are derived from common parents."

(p. 406) "All individuals of the same species. . . . are descended from common parents."

On the other hand we have the following passage :

(p. 322). . . . "Individuals of the same species inhabiting the same area will be kept nearly uniform by intercrossing ; so that many individuals will go on simultaneously changing, and the whole amount of modification at each stage will not be due to descent from a single parent."

This last passage, though somewhat ambiguous, leaves us in some doubt whether Darwin held that species are to be traced back to a single ancestor or ancestral couple, but they leave no doubt but that he was of opinion that each species originated in a single locality from which it spread by migration.

II. On the closely allied point as to the existence in the individuals of species of a tendency to parallel variations there is a somewhat similar though less uncertainty as to Darwin's final opinion.

Thus, on page 125, he heads a paragraph with the words :

Distinct species present analogous variations, so that a variety of one species often assumes a character proper to an allied species.

This he illustrates by the frequent occurrence in one breed of domestic pigeons of a characteristic of another breed, but not found among the aboriginal rock pigeons from which both have descended, as for example the occurrence of fourteen or sixteen tail feathers in

the pouter, thus assimilating it in this respect to the fantail, and he adds the words :

> "I presume that no one will doubt that all such analogous variations are due to the several races of pigeons having inherited from a common parent the same constitution and *tendency to variation*, when acted on by similar unknown influences."

And after mentioning other instances of analogous variation he goes on to add :

> "According to the ordinary view of each species having been independently created we should have to attribute this similarity . . . . not to the *vera causa* of community of descent and a *consequent tendency to vary in a like manner*, but to three separate yet closely related acts of creation."

Again on page 127 we find the passage :

> "The difficulty of distinguishing variable species is largely due to the varieties, mocking as it were other species of the same genus" . . . .
>
> "But the best evidence of analogous variation is afforded by parts or organs which are generally constant in character, but which occasionally vary so as to resemble in some degree the same part or organ in an allied species. I have collected a long list of such cases."

Now it is obvious that if the individuals of allied species shew this tendency to parallel variation such tendency must be far stronger among individuals of the same species and still more among individuals of the same variety, and accordingly on page 91 Darwin says :

> "The tendency to variability is itself hereditary, consequently they" (*i.e.* the individuals belonging to varieties of a species) "will likewise tend to vary, and commonly in the same manner as did their parents."

These passages seem to prove almost conclusively that Darwin held that varying species have a tendency to vary in particular lines, determined by those lines of variation which have evolved the species itself.

On the other hand, however, there are passages in which Darwin seems explicitly to deny the existence of a general tendency to simultaneous variation.

Thus on page 319 we read :

> " There is no evidence, as was remarked in the last chapter, of the existence of any law of necessary development."

And on page 291 :

> " These several facts accord well with our theory which includes no fixed law of development, causing all the inhabitants of an area to change abruptly or simultaneously, or to an equal degree."

If, however, these passages be carefully read with the context it will appear that the law of development here denied is not one affecting the individuals of particular species only but the individuals of all species inhabiting a given area.

Nevertheless the following passage seems to shew that at the time of the publication of the first and earlier editions Darwin believed that species did originate from the casual variation of an individual, and that it was only after the year 1867 that he came to the conclusion that new permanent varieties and consequently new species could only be formed by similar and simultaneous variation in many individuals of the same species.

In the IVth Chapter of the 6th edition, page 71, after illustrating the action of natural selection by the example of the swiftest and slimmest wolves alone being able under certain circumstances to subsist and propagate their race, he goes on to say :

> " It should be observed that in the above illustration I speak of the slimmest individual wolves, and not of any single strongly marked variation being preserved. In former editions of this work I sometimes spoke as if the latter alternative had frequently occurred " . . . " until reading an able and valuable article in the North British Review 1867 I did not appreciate how rarely single variations whether slight or strongly marked could be perpetuated" . . . .
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> " It should not . . . . be overlooked that certain rather strongly marked variations, which no one would rank as mere individual differences, frequently occur owing to a similar organization being similarly acted on." . . . .
>
> " *There can be little doubt but that the tendency to vary in the same manner has often been so strong that all the individuals of the same species have been similarly modified without the aid of any form of selection.*"

These passages would naturally lead to the conclusion that Darwin originally believed that varieties and species originated from some casual change in an individual, but subsequently came to the conclusion that varieties and species could only establish themselves by the simultaneous like variations of many. There is however a passage in the sixth edition of the "Origin of Species," which occurring as it does in the final summary (p. 423) seems to render this conclusion again somewhat doubtful.

Darwin is treating of the theory of the descent of organic life from an individual primordial form.

> "It has, he writes, been maintained by several authors that it is as easy to believe in the creation of a million beings as of one, but Maupertuis' philosophical axiom of "least action" leads the mind more willingly to admit the smaller number; and certainly we ought not to believe that innumerable beings within each great class have been created with plain but deceptive marks of descent from a single parent."

Here clearly Darwin regards the possession of similar characteristics as conclusively proving descent from the same ancestor.

The balance of evidence seems, however, on the whole to be in favour of the conclusion that as far as existing species are concerned, Darwin held that they have been evolved subject to selection, by the tendency among individuals of pre-existing species to simultaneous variation in some limited number of directions determined by a subjective cause which may be termed hereditary influence.

If then we recollect that Darwin held (p. 42) that wide-ranging, much-diffused and common species vary most, it seems almost impossible to avoid the conclusion that according to Darwin's theory new variations in the same direction will occur over the area or in the different areas over which the species is diffused and will develope into like specific forms wherever surrounding circumstances are not unfavourable, whether it be in one locality or many.

In confirmation of this view we may quote the following passage (Origin of Species, p. 419):

> "The existence of closely allied or representative species in any two areas implies on the theory of descent with modification that the same parent forms previously inhabited both areas, and we almost invariably find that whenever many closely allied species inhabit two areas some identical species are common to both."

Darwin himself explains this by supposing that of the identical species formerly occupying these two areas, some have varied and some have not, those which have varied being now allied species, those which have not varied being identical species.

But as according to him widely diffused species are varying species, it seems more in accordance with probability to hold that the closely allied species are those which have varied from the common parent in slightly different directions in the two areas, while the identical species are those which have varied still more closely. At any rate it seems impossible to deny that simultaneous parallel variation is a *vera causa* for the existence of widely diffused species.

ORIGIN OF LIFE.

Let us now examine whether Darwin's theory as to the origin of organic life on the earth throws any light on his views as to subjective variational tendencies.

In the first edition of the "Origin of Species," page 484, we find the following passages :

> "I believe that animals have descended from at most only four or five progenitors, and plants from an equal or lesser number."
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> * * * * * *
>
> "I should infer from analogy that probably all the organic beings which have ever lived on this earth have descended from some one primordial form, into which life was first breathed."

In the sixth edition, pages 424 and 425, similar passages occur, only that for the second passage the words *into which life was first breathed* are omitted.

Are we to understand from this that Darwin regarded the origin of organic life on the earth as supernatural? If the words "into which life was first breathed" which appear in the first edition seem to imply the attribution of a supernatural origin to organic life, their omission in the sixth edition might be regarded as showing a desire on Darwin's part not to commit himself to any such theory. On the other hand, however, the following passage, also from the same edition, seems to point to a different conclusion. On page 423 we find the words :

> "It has been maintained by several authors that it is as easy to believe in the creation of a million beings as of one, but Maupertuis' philosophical axiom of 'least action' leads the mind more willingly to admit the smaller number."

These words seem to be only consistent with the well-known theological doctrine of "economy of miracles" and one would be inclined to conclude from them that Darwin considered that origin of organic life on the earth was supernatural.

The mere fact moreover of Darwin tracing back all organic life to one or at the most a dozen primordial progenitors seems inconsistent with any hypothesis but that of his believing in the supernatural origin of life. If life originated from inorganic matter according to a natural law it is quite incredible that this law in all earthly time and space should have operated only once or even at most a dozen times.

Assuming then that Darwin regarded the origin of organic life on the earth as supernatural, it is obviously in vain to look to his views in this respect for any light it may throw on the origin of species.

But though Darwin's views cannot assist us in this respect, it may be of some use to consider the subject on its own merits.

Setting aside the theory of supernatural origin of life, not as being untrue or improbable but as putting the question out of the reach of scientific enquiry, there are three other hypotheses on this subject which seem worth consideration:

(1.) Organic life always existed on the earth.

(2.) Organic life came to the earth by migration.

(3.) Organic life originated and perhaps still continues to originate according to some natural law.

Let us consider each of these hypotheses in turn.

(*1.*) *Organic Life always existed on the Earth.*

Against the first hypothesis it may be urged:

I. The perpetual existence of life on the Earth is inconceivable Everything must have had a beginning, therefore organic life on the Earth must have had a beginning.

II. The perpetual existence of organic life on the Earth is inconsistent with La Place's theory of the origin of our planetary system, according to which theory the Earth must at one time have been in a physical condition inconsistent with the existence of organic life in any form known to us or from which it is at all probable that existing life would have been derived.

I. To the first of these objections the reply is that the word inconceivable is here misused. No doubt the forms of things as we observe them are always changing, and in this sense we are constrained to believe that all that exists is transitory. On the other hand, however, we are equally constrained to believe in the continuity

of the present with the past, and we cannot realize a time when nothing existed and something came out of this nothing. An infinite period of vacuity ending with a creation is in the highest degree incredible, and if we are precluded from ascribing a beginning to the universe as a whole we cannot be compelled to ascribe a beginning to organic life either generally or on the Earth.

II. As to La Place's theory it must be remembered that it is only a theory, and that recent discoveries in Astronomy and Geology have not rendered it more plausible.

Geology points to changes in the Earth's temperature, but certainly not to continuous change in one direction. If in the Arctic regions there are indications of there having been a higher average temperature in certain remote geological periods, there are no less clear indications of a lower temperature having prevailed in regions now temperate or even tropical. Geology moreover claims for the formation of the Earth's crust as known to us periods of time which the physicist arguing from La Place's theory will not for a moment allow.

So also in Astronomy the observed motions of some of the Asteroids and Satellites are admittedly at variance with the truth of La Place's theory.

On the whole therefore it would seem that the theory of the eternal existence of organic life on the Earth is not one that is to be summarily rejected as inconceivable or impossible, at the same time it is obvious that this theory is incapable of throwing any light on the laws of evolution, as might indeed be concluded from the consideration that what we call infinite is negative or at least privative and not positive.

(*2.*) *Organic Life came to the Earth by Migration.*

I. Some seem to think that this hypothesis is altogether unworthy of consideration, and it must be admitted that it is very difficult to understand how any form of organic life that we are acquainted with can have been brought to the earth from without. It would perhaps, however, be too much to say that such a thing is impossible, though we may safely conclude that if it has happened it is in the highest degree improbable that it has happened only a few times. We are perhaps too ready in placing the boundary of the possible at the limits of our perceptions. We forget that in the minutest particle of meteoric dust there is, in a sense, as much room as there is in a planet, and that we have not the least reason to suppose that organic forms are limited as

to size by the perceptions of our senses, even though aided by instruments a million times more powerful than the best devised by man. It is as well to remember that the abysses of the infinitely little are really as profound as those of the infinitely great, that if our telescopes reveal to us ever-increasing profoundities of distance, our microscopes equally reveal to us the profoundities of minuteness, and in neither direction do we find trace nor can we conceive any possibility of limit.

II. The migrationary hypothesis may likewise be objected to on the ground that it merely removes the problem as to the origin of organic forms to some other time and place. This is true, but the hypothesis of the co-eternal existence of organic and inorganic forms in the universe as a whole does seem to present fewer difficulties than their co-eternal existence on the Earth.

Moreover we are not now concerned with the relative probability of the various hypotheses as to the origin of organic life, but with the light which these hypotheses respectively throw on the theory of subjective tendency to variation. Whether the migrationary hypothesis is or is not satisfactory as to the origin of life, all we are concerned about is whether this hypothesis supposes the introduction of life on the earth in one or only a few cases, or in an indefinite number of cases, and it can hardly be denied that the latter is the case.

(*3.*) *Organic Life originated and perhaps still originates from Inorganic Life according to some Natural Law of Continuity.*

This hypothesis, sometimes called that of Spontaneous Generation is summarily rejected by some as being inconceivable. Here again the word inconceivable is wrongly used. There can be no difficulty in the conception of continuity between what is called the organic and the inorganic forms of matter, though there may be some difficulty in believing that such continuity actually exists, since all our experience goes to shew that organic forms invariably proceed from previously existing organic forms. This difficulty would, however, be somewhat diminished by the reflection that our experience imperfectly covers only an infinitesimal part of nature. Because physicists have not yet consciously succeeded in producing organic from inorganic forms in the glass bottles of their laboratories, it by no means follows that in the wonderfully diversified conditions which exist and have existed on the Earth, such production is

impossible. As already observed, in the boundless field of the infinitely little there are infinite possibilities. The doctrine of spontaneous generation has never been disproved, and probably never can be disproved, though the too hasty conclusions of some physicists who have claimed to produce the necessary conditions for the passage from the inorganic to the organic forms have been successfully disproved.

To summarise these results, it may be said that the hypotheses of the supernatural creation of organic life, or of its perpetual existence on the Earth, throw no light on its subsequent evolution, but the hypotheses of the introduction of organic life by migration or spontaneous generation seem inevitably to lead to the conclusion that life has originated on the Earth, not as Darwin supposes from one or a dozen ancestors, but that the process of life introduction is one that is continually going on, or at any rate must have happened a countless number of times. Whether the *forms* of life thus introduced are countless is another question. If it be permitted us to reason about matter so entirely beyond our experience, we might infer from analogy that the process of what may be called organic crystallization is possible in only a limited number of ways so that the number of forms produced by spontaneous generation, if such generation exists, would be comparatively few. If the migration theory be true, then on the other hand there would seem to be no limit to the number of forms that might be introduced.

If the migration theory be maintained then the Darwinian hypothesis may be sufficient by itself to account for the present state of terrestrial organic life, since the immigrant forms may have brought with them the hereditary tendency to vary in specific lines.

If, however, the doctrine of spontaneous generation be maintained, then we seem compelled to supplement Darwin's hereditary tendency to specific variation by Lamark's theory of a purely subjective tendency to specific variations, supplemented by Darwin's theory as to the objective control of such subjective tendency ; but, whether we accept Darwin's theory alone or use it as a supplement to Lamark's, whether on account of heredity or on account of heredity and subjective law combined, we are driven to the conclusion that *the tendency is to variation in specific directions, and consequently to the independent origination of the same varieties, and therefore of the same species and genera, so that independent simultaneous variation must be admitted as a vera causa for the existence of widespread species.*